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APPLICATION NUMBER: ***60/533,305***
FILING DATE: ***December 30, 2003***
RELATED PCT APPLICATION NUMBER: ***PCT/US04/43408***

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22855 U.S. PTO
123003

PTO/SB/16 (08-03)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EV 301746865 US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
John J.	Keating III	Hoboken, NJ

☒ *Additional inventors are being named on the* 1 *separately numbered sheets attached hereto*

031356 U.S. PTO
60/533305
123003

TITLE OF THE INVENTION (500 characters max)

Image Scanner Realtime Calibration of Stereographic Images

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 14 — ☐ CD(s), Number

☒ Drawing(s) *Number of Sheets* 4 — ☐ Other (specify)

☐ Application Data Sheet. See 37 CFR 1.76

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Respectfully submitted,

SIGNATURE Allen N Friedman

Date 12/30/03

TYPED or PRINTED NAME Allen N. Friedman, Esq.

REGISTRATION NO. (if appropriate) 25,973

Docket Number: 97084/00049

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Docket Number	97084/00049

INVENTOR(S)/APPLICANT(S)

Given Name (first and middle [if any])	Family or Surname	Residence (City and either State or Foreign Country)
Rainer	Martini	Hoboken, NJ

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Effective 10/01/2003. Patent fees are subject to annual revision.

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TOTAL AMOUNT OF PAYMENT ($) $80.00

Complete if Known	
Application Number	To be assigned.
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First Named Inventor	John J. Keating III
Examiner Name	To be assigned.
Art Unit	To be assigned.
Attorney Docket No.	97084/00049

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1. BASIC FILING FEE

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1001	770	2001	385	Utility filing fee	
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
1004	770	2004	385	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	80.00

SUBTOTAL (1) ($) $80.00

2. EXTRA CLAIM FEES FOR UTILITY AND

	Extra Claims			Fee from below		Fee Paid
Total Claims	-20** =	0	X		=	0.00
Independent Claims	- 3** =	0	X		=	0.00
Multiple Dependent					=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

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FEE CALCULATION (continued)

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1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet	
1053	130	1053	130	Non - English specification	
1812	2,520	1812	2,520	For filing a request for *ex parte* reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1,005	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	
1402	330	2402	165	Filing a brief in support of an appeal	
1403	290	2403	145	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive - unavoidable	
1453	1,330	2453	665	Petition to revive - unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR § 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Statement	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR § 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37 CFR § 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
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Name *(Print/Type)*	Allen N. Friedman, Esq.	Registration No. *(Attorney/Agent)*	25,973	Telephone	973-639-6946
Signature	Allen N. Friedman			Date	12/30/2003

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97084-00049

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of
JOHN J. KEATING III, ET AL.

Serial No.: TO BE ASSIGNED

Filed: FILED HEREWITH

For: IMAGE SCANNER REALTIME CALIBRATION OF STEROGRAPHIC IMAGES

X

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Stephanie B. Drabyk

Stephanie B. Drabyk

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

PROVISIONAL APPLICATION

Inventors: John J. Keating III, Rainer Martini,

Both residing at 613 Hudson Street, Hoboken NJ 07030

Title: Image Scanner Realtime Calibration of Stereographic Images

1. **Background of the Invention:** In developing an invention disclosure for a 3D image scanner using ultra short pulses, it was realized that the calibration of the optical equipment, especially those configurations using multiple cameras is a very time consuming process and that the cost of three dimensional (3D) imaging equipment could be reduced if a more efficient calibration equipment were available. This invention employs a holographic projection to which multiple image recorders are aligned by physical alignment or by software post processing of the images produced by stereoscopic imaging capturing devices.
2. **Purposes and advantages of invention:** This invention provides apparatus and methods to calibrate stereoscopic optical recording equipment, in realtime, for both optical and electronic based optical recorders. Stereoscopic Equipment includes two or more optical recorders or a single optical recorder sequentially moved to different positions in space to acquire images of one or more desired objects. Calibration Equipment improves the quality of the stereoscopic images, for example, by more accurately combining information from multiple Optical Recording Devices. The herein described Calibration Equipment is both an apparatus to use with image capture equipment such as cameras and a method to compensate for the absolute and/or differential distortion within and across stereoscopic imaging equipment used together as a system.

   One potential use of the higher quality images obtained from calibration/compensation is to more accurately determine the distance to points on the stereoscopically recorded or viewed object for uses which include the construction of three dimensional images of desired

object. As this equipment is capable of providing calibration during normal stereoptic operation, without affecting the desired image, it is usable for continuous calibration, for example, when the stereoptic imaging devices are equipped with variable zoom lenses that exhibit differing optical properties as the zoom setting is changed or continuous calibration during normal operation when mechanically misalignment of equipment occurs in one or more of the optical paths to the Optical Recording Devices.

3. **Description:** The calibration of the three dimensional stereoscopic imaging equipment normally requires the calibration for all points in the target space occupied by the Desired Object to be captured as a three dimensional image, a time consuming process that is repeated for each change of the equipment in the optical path between the recorded objects and the image recording devices. To overcome this problem this disclosure describes an apparatus employing a holographic projection technique that creates a virtual object in the target space and therefore automates the calibration process. As this virtual image is viewed by the same lens system used for the stereoptic imaging systems, all static distortion will be taken into account. Changing the Holographic Calibration Pattern (image) is accomplished by recording multiple, superimposed holograms at different wavelength(s) or different positions on the Holographic Calibration Plate and then choosing a specific calibration pattern by illuminating the Holographic Calibration Plate by the specific wavelength(s) corresponding to the specific calibration pattern or viewing from a specific position. This apparatus and method allows for calibration at selectable and assignable positions in the Desired Object three dimensional target space. The hologram allows explicit calibration in the target space without the limitations of using real calibration objects that are moved through the image space as a calibration method. This holographic calibration system envisions the use of fixed holographic images or variable plate (e.g. using external inputs to phase modulate the holographic plate) holograms.

4. **Physical Arrangement**:

In Figure 1, starting with the three dimensional physical object with normal background illumination, such as the three dimension pyramid shown in Figure 1, reflected light from the object travels toward the stereoscopic system, first passing through a Holographic Calibration Plate that is transparent to light in the desired range (e.g., normal visible light reflected from the Desired Object, which in Figure 1 is a pyramid, so as not to effect the recording of light of the Desired Wavelengths by the Optical Recorder(s). Let us refer to the light from the Desired Object whose image is desired(e.g. the pyramid in Figure 1) as the Desired Wavelengths. Let us refer the wavelengths produced the Holographic Calibration Plate, the Virtual Calibration Object as the Calibration Wavelengths. The Desired Wavelengths passing through the Holographic Calibration Plate [abcd] which will contain holographic encoded calibration information. This calibration information is in the Desired Wavelength region for applications in which the calibration information overlays the Desired Wavelength information so that both the Desired Object and the hologram be simultaneously observable without additional post processing. For applications in which the Desired Wavelengths alone are desired, the Calibration Wavelengths are stored or processed separately from the Desired Wavelength information. Calibration information and Desired information at overlapping wavelengths can also be temporally separated by pulsing the Calibration information for short times and synchronizing observation of the Calibration information.

The calibration patterns are encoded into the calibration hologram and made recordable and storable by the optical sensors by illuminating the hologram [abcd] in Figure 1 with an independent light source, S1 in Figure 1, which may be on either side of the hologram, thus ensuring the incorporation of the Holographic Calibration image into the camera field of view. Through movement of holographic plate or by changing of the illumination parameters (e.g. frequency of S1), alternative calibration information is generated for processing by the Optical Recorder.

Figure 1a is a variation of Figure 1 that uses a Mirror M1 to reflect the holographic image from Hologram M1, e.g. correction image, to the one or more Optical Recorders R1, R2, and

R3. The mirror M1 is reflective at the calibration wavelengths and transparent at the desired wavelengths, thus images from the desired object, e.g. the pyramid in Figure 1a, pass directly to the Optical Recorders. This variation enables the use of wavelengths in light source S1 that included the desired wavelengths, as the desired wavelengths from S1 will pass directly through the Mirror M1 and are not reflected to the Optical Recorders.

In the case where the Holographic Calibration Wavelengths are different from the Desired Wavelengths (the normal case for this apparatus, although some applications may choose a Calibration Wavelength within the range of the Desired Wavelengths), the images reaching the Optical Recorders Device shown in Figure 1 contains both the Desired Object Wavelengths and Calibration Wavelengths.

The Optical Recorder equipment is this disclosure is of two types:

1. For Optical Recorder Device (apparatus), shown in Figure 2, the composite image of Desired and Calibration Wavelengths enters each Optical Recorder Device and is separated inside the Optical Recorder using additional wavelength selective filters and the Desired Wavelengths and the Calibration Wavelengths are processed separately within the Optical Recording Device. Selective separation of the optical wavelengths is of multiple subtypes. Type 1a uses optical filters to selectively separate the wavelengths. Type 1b uses a special optical to electron converts such as CCD arrays to separate the wavelengths, that is, the pixel array that provides optical to electronic conversion uses a planar arrangement of light sensitive devices whose arrangement in two dimensions alternates devices whose sensitivity peaks for Desired and Calibration Wavelengths. Type 1c splits the optical signal and optical band pass and Bandstop filters select the Desired Wavelengths and the Calibration Wavelengths.

2. In Type 2 Optical Recorder equipment, shown in Figure 3, the calibration image wavelengths are generated only for special frames. Frames imply that the recording of the desired and calibration optical images is broken into discrete units of time during which subsequent samples of the Desired Wavelengths and Calibration Wavelengths are captured. Special frames store the Calibration Wavelengths. The special frames are of Type A which are stored or processed separately from the desired frames or Type B which are interspersed, at a periodic or non periodic rate, between the frames that contain the Desired Wavelengths. Figure 3 shows the equipment that utilizes Type 2 Optical Recorders. In Figure 3, Hologram Source S2 is pulsed on during the special frames and the optical or mechanical shutter OS1 is closed during special frames. This arrangement enables the recording of desired and calibration information without the wavelength separation described in Figure 1. The apparatus in Figure 3 more easily enables multiple calibration patterns based on Calibration Wavelengths above and below the Desired Wavelengths than the apparatus described above in Figure 1 in which additional wavelength selective filters are required.

   The Type 2 apparatus permits a pulsed synchronization source in the field of view to provide pulsed time code information for synchronizing multiple cameras and/or to convey synchronized instructions to the multiple stereoptic cameras simultaneously, e.g. for special effects and other camera related functions. The combination of synchronization and holographic calibration/alignment across multiple cameras permits a more cost effective implementation of panoramic cameras such as those that are now achieved mechanically in CineMax systems and the simplified construction of panoramic three dimensional imaging devices.

The apparatus described above in Figures 1, 1a, 2 and 3 generates, in each Optical Recorder in the system, an image of the Desired Object and an image of the Virtual

Calibration Object. For each mechanical configuration of the Optical Recorders, e.g. physical position or optical magnification setting, the calibration method is a follows:

1. Choose one Optical Recorder as the reference and assign a coordinate system. For an electronic image detector within the Optical Recorder assign the coordinates in parallel or normal to the pixel array in the camera or in alignment with the Holographic Calibration Plate pattern. For a non-electronic system, assign the coordinate system arbitrarily or in alignment with the holographic calibration pattern.
2. Assign the same coordinate system to all other Optical Recorders and measure the difference in the hologram calibration pattern in this coordinate system.
3. Utilize the differences measured on this coordinate system to calculate the calibration corrections for each Optical Recorder relative to the reference Optical Recorder.
4. Use the calibration corrections to compensate the desired images either mechanically or electronically.

When a single Optical Recorder is used sequentially in different spatial positions, the above procedure changes as follows: The first position becomes the reference and each subsequent position is treated in the calibration method as an additional Optical Recorder.

The Optical Recorder Device, shown in Figure 2, is capable of processing the image of a calibrated desired object in real time by translating, rotating and scaling the Desired Object Image based on the Calibration Image or storing the Calibration Images and Desired Object Images independently for delayed processing.

The Holographic Calibration Plate [abcd] in the Figures 1 and 3 need not be flat or continuously connected. A single Optical Recorder or multiple Optical Recorders may use a spherical, cylindrical or arbitrarily shaped hologram, illuminated by Source S1 from either the inside or outside of the plate that surrounds or partially surrounds the Desired

Object. As an example, Figure 4 shows a single Optical Recorder that moves around the outside of the cylindrical holographic calibration plate and generates successive images of the object that are post processed into a stereoptic image or into a three dimensional model of the object using algorithms for color and or edge matching. These stereoptic images of the object can be used to capture the 3 dimensional shape of the object from calculation using as input successive images of the Desired Object, and the spatial position of uniquely determined points on the object, e.g. points for a wire frame model, is calculated by triangulation. Color, texture and shading are then applied to the wire frame model from the captured images of the object.

Specific points on the objects are uniquely determined by highlight the desired points with points painted, points where an application pattern is projected on to the object using a calibration wavelength or with calibration points attached to the object which are painted with the calibration wavelengths. For example, to use this apparatus to measure a person for shoes or clothing, the person puts on a pair or socks or a tights that are painted with an application pattern, e.g. grid, in one or more calibration wavelengths. The image matching, for one or more cameras, is precise at the calibration grid points. Alternatively, a cosmetic surgeon may paint a selected pattern on the patient using paint in a calibration wavelength that is not visible to the human eye, or project a pattern on the patient using calibration wavelengths. This allows the surgeon to view normal visible images of the patient that have the selected pattern visible in post processing for either still or full motion images. Surgeons may also use these techniques in conjunction with thermal images when the desired wavelengths are properly selected, for radiological treatment application where heat is generated by radioactive treatment materials.

Optical Recorders which separate the desired and Calibration Wavelengths enable efficient extraction of the objects color and texture in addition to its three dimensional shape. Figure 5 shows the use of three Optical Recorders which can capture and triangulate the position in three dimensional space of a point P which is illuminated by a laser using a Calibration Wavelength, and thus invisible at Desired Wavelenths. This is an improvement over stereoptic color matching or edge matching, as the point P is precise. Furthermore, when combined with holographic calibration techniques, this apparatus improves the ease and accuracy of the three dimensional shape resolutions that is the position of point P can be inferred from its position relative to the Virtual Holographic Pattern. As the processing of the object color and texture information is independent of the spatial information this technique this apparatus captures both the objects shape and texture. Combining a holographic measurement grid with the point in illuminated at a Calibration Wavelength provides an apparatus that can measure an objects shape with a single Optical Recorder and provide increased speed and accuracy with multiple Optical Recorders.

The apparatus uses the Virtual Calibration Pattern to position the Laser Pointer, L1 at desired points on the Virtual Calibration Pattern. For example, if the Virtual Calibration Pattern is a grid on a plane that intersects the Desired Object and the laser generated point P is to be positioned on the surface of the object at all points at the grid intersection points nearest to the spatial positions where the virtual grid intersects the Desired Object, the following procedure is followed;

1. Choose a Virtual Calibration Pattern grid on a plane that is tangent to the nearest point of the Desired Object as measured from the Optical Recorder
2. Label the subset of virtual grid intersection points defined by those closest to where the virtual grid intersects the desired object in some numerical order.

3. Starting with the first numbered point and continuing to the last numbered point, position the laser point P at each numbered point successively and collect the position data using measurements to the calibration pattern. The apparatus simplifies the positioning process since the laser pointer wavelength is a Calibration Pattern Wavelength and the Pointer position P and the Virtual Calibration Pattern are simultaneously observable by the control system for the laser pointer and thus relative positioning corrections rather than absolute position Laser Pointing system are required.
4. Generate successive Virtual Calibration Pattern grids that intersect the Desired Object at greater distances from the Optical Recorder and repeat steps 2 and 3.
5. Continue until the Virtual Calibrating Pattern girds no longer intersect the Virtual Object

Figure 6 shows the combination of the holographic calibration with a Laser Ranging Measurement Device LRMD1. This apparatus combines a Laser Ranging Measurement Device with holographic three dimensional calibration using one or more Optical Recorders. The Laser Ranging Measurement Device LRMD1 provides accurate ranges to any point P on the surface of the Desired Object. The holographic calibration grid is used to provide accurate measurements of point P relative to optical images gathered from the Desired Object. By choosing a wavelength for the Laser Ranging Measurement Device LRMD1 that is a Calibration Wavelength, the point P illuminated by the LRMD1 is observable at the same time as the calibration pattern. The Laser Ranging Measurement Device is positioned using the procedure described with reference to Figure 5.

Figure 7 shows the use of a spherical calibration hologram that generates a calibration grid, e.g. a spherical coordinate grid, around one or more Optical Recording Devices. Apparatus in this configuration are well suited to applications requiring a complete field of

view. Multiple Optical Recorders can be placed within the calibration hologram to simultaneously cover all directions although this requires appropriate handling of overlapping fields of vision between adjacent Optical Recording Devices. The Calibration Hologram provides the mechanism to overcome the problems of adjacent Optical Recording Devices, including overlapping fields and conformal mapping from the planar segment of the optical recording device to a spherical frame of reference, and also provides a holographic pattern to provide the basis for conformal mapping of the Optical Recorder Outputs. The holographic calibration pattern provides boundaries between adjacent Optical Recording Devices and provides a uniform coordinate system across all devices that enables simplified calibration and alignment of conformal mapping across Optical Recording Devices, especially when the alignment between such devices are varying due to shock, vibration or acceleration. The Spherical Calibration Hologram, when combined with the laser ranging of Figure 6 provides accurate ranging to a targeted object.

This spherical holographic calibration configuration provides an apparatus to generate an input for a panoramic 360 degree view of remotely piloted vehicles subject to shock or acceleration. The apparatus enables realtime compensation for the two major problems of providing a panoramic 360 degree view for remotely piloted vehicles, that is, continuous alignment of multiple "fisheye" cameras as such cameras and related optics are subject to misalignment by shock or vibration, and the conformal mapping of multiple cameras into a 360 degree panoramic view. Furthermore the Calibration Wavelengths can be chosen to include wavelength used in collision avoidance systems and thus process such information jointly with the Optical Recorder calibration.

Figure 8 shows the use of non continuous, identical holographic calibration plates. If these plates were held mechanically parallel, then this configuration would effectively be the configuration of Figure 1. Misalignment of the calibration plates shifts the calibration pattern

up or down, left or right and/or forward or back. Thus the misalignment may be calculated from a set of reference points in the field of view. These points my be known calibration points, such as fixed points in the field of view, points projected by a laser whose wavelength is a Calibration Wavelength or some distinctive feature of the Desired Object such as an edge or point of distinct color point. The calibration algorithm is as follows:

1. Fix the separate holographic correction plates rigidly as closely as possible to the configuration of single fixed plate For flat calibration plates this implies initially fixing the non-contiguous plates as parallel to each other as possible. For cylindrical/spherical segmented non-contiguous plates this implies initially fixing the plates rigidly as close the location which a contiguous cylindrical/spherical plate would occupy, and so forth for other shapes of holographic plates such as elliptical.
2. Determine a number of reference points in the vicinity of the Desired Object, if not on the Desired Object itself. Illuminated points on the Desired Object are a subset of these conditions. Additional fixed calibration points are generated by affixing reflecting and/or absorbing colors to the Desired Object with wavelengths in the calibration range, thus predetermining a fixed set of points for calibration.
3. For each reference point, determine the corresponding position on the Holographic Compensation Pattern and determine the misalignment of the hologram.
4. Determine the correction factors, for example, shift, rotation and scaling in an orthogonal coordinate system, as a function of position in the Desired Object in three Dimensional space, for each Optical Recording Device.
5. Applied the corrections for each Optical Recording Device to both the Holographic Calibration Patterns and the Desired Objects.

An alternative configuration of the apparatus is realizable, for applications that do not utilize the patterns of the Holographic Correction Plate. Specific reference points in the field of view

of the Desired Object are illuminated by a remote source or self illuminated with Calibration Wavelengths. These points are separated into Calibration Wavelengths by the apparatus and are used to provide calibration across the Optical Recorders and provide the calibration for compensation of the Desired Object. That is, in some circumstances, fixed calibration points near or on the desired object may replace the Holographic Calibration Plate.

For applications that do not utilize the patterns of the Holographic Calibration Plate, and where specific reference points can be illuminated by a remote source or self illuminated with Calibration Wavelengths the holographic plate is not a required part of the apparatus. Only the parts of the apparatus that separates the Desired Object wavelengths from Calibration Wavelengths is required. The calibration corrections for each Optical Recorder are calculated from the known points illuminated by the Calibration Wavelengths for each of the stereoptic Optical Recorders and calibration corrections are applied to each of the Desired Object in each Optical Recorder. This simplified calibration and compensation method is more likely to be employed only in wide angle images that uniformly capture many fixed calibration sources and where the fixed points are affixed to Desired Objects or placed near to stationary Desired Objects.

Figure 9 shows the addition of a Bandstop Filter to the apparatus of Figure 1, which prevents the illumination wavelength(s) of Hologram Source(s) from traveling from the apparatus to the region in the vicinity of the Desired Object. Such emanations from the apparatus are an undesirable circumstance when the apparatus is used in a security or a surveillance application.

Figure 10 show an apparatus which generates virtual holograms with stereoptic microscopes. While the calibration of the two optical paths in a microscope is not important due to the excellent mechanical construction of microscopes, the calibration is more useful when multiple optical paths are employed and in addition, the ability to project a hologram is both

novel and useful. Potential uses include projecting grids to assist in counting specimens such as while blood cells on microscope slides or projecting three dimension grids to ascertain the locations of imperfections in diamonds as a means of grading and identification in the case of theft. The use of three dimensional holograms permits improved analysis as stereoptic microscope images are scaled, especially in the depth dimension.

When multiple holographic patterns are recorded on the Holographic Calibration Plate, these patters are selectively accessed as the wavelength of the illumination of the Holographic Calibration Plate is varied or by movement of the plate. One problem with a grid is that unless the grid intersections are somehow labeled, errors in identifying a particular intersection are possible. This apparatus uses one Calibration Wavelength to record the grid and another Calibration Wavelength to symbolically identify the grid intersection, e.g. a bar code or alphanumeric sequence, and additional wavelengths with finer grid structures for more accurate determination of three dimensional spatial positioning. Combining the Holographic Calibration Plate with a symbolic identification such a bar code decreases the time for real time recognition of grid intersections by commercial software.

5. **Ramifications:** This invention provides continuous (realtime) calibration of stereo optic information from still or moving objects. It improves the quality of the stereo optic images and permits the construction of more accurate three dimensional models from such images.

By changing the calibration patterns, for example by varying the hologram frequency when alternative holograms are recorded at different frequencies, several ranges and positions of the image field of view can be continuously recalibrated to compensate for variations in image system distortions (e.g. as the degree of telephoto magnification is changed).

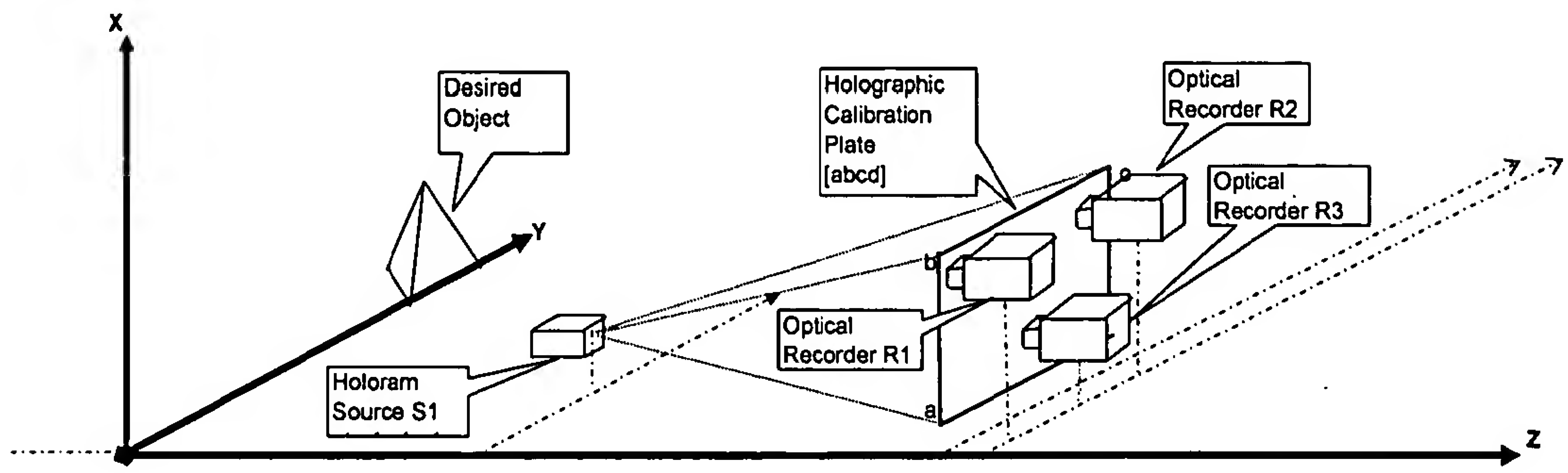
Compared to standard calibration systems this technique offers many possibilities. In a standard calibration procedure a real object has to be brought in all possible positions to obtain a full calibration – which is typically very time consuming and some positions are not accessible at all – and therefore cannot be calibrated. As consequence the calibration is time consuming. Any changes to the recording apparatus after the calibration will void this calibration and reduce the accuracy of the 3D information. With this new apparatus, the Virtual Holographic Calibration Pattern can be produced in any place in the field of view of the optical recording devices and the calibration is done quickly.

Compared with other calibration systems, the desired information and the calibration information are recorded through the same lens of each image recorder as the desired image is captured at the same time as the calibration image, and this enables real time calibration as post processing.

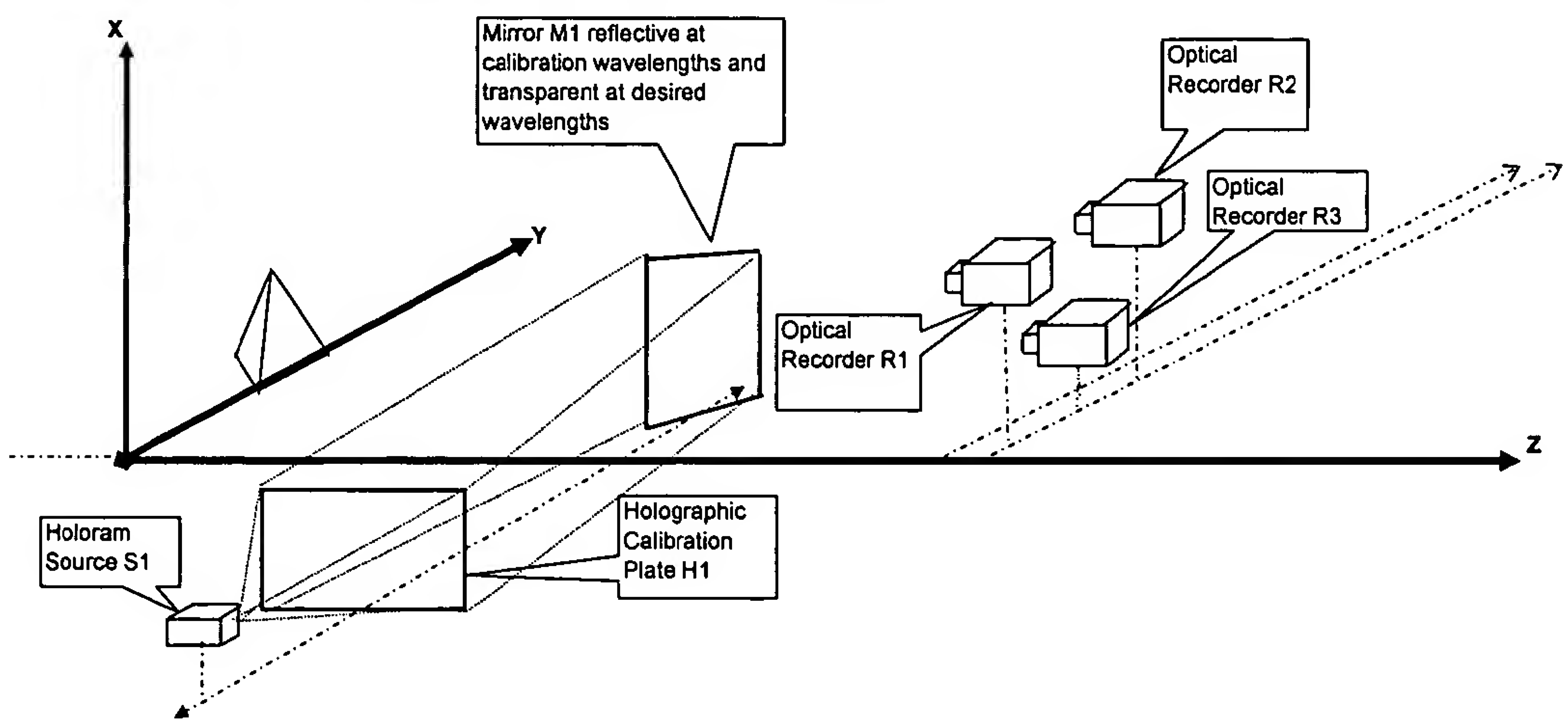
The Calibration Equipment and methodology continuously operate without interfering with the Optical Recording Devices.

Figures

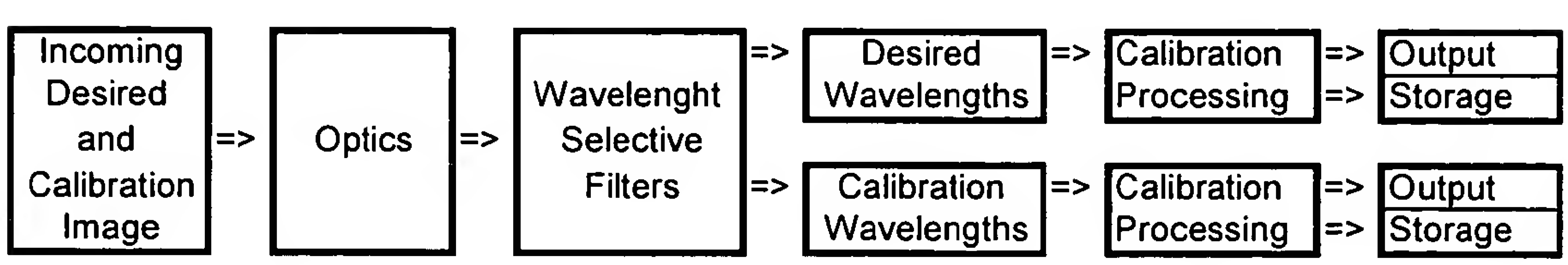
Concept for Alignment and Calibration of Image Scanner with Multiple Optical Recorders using Holograms
Figure 1



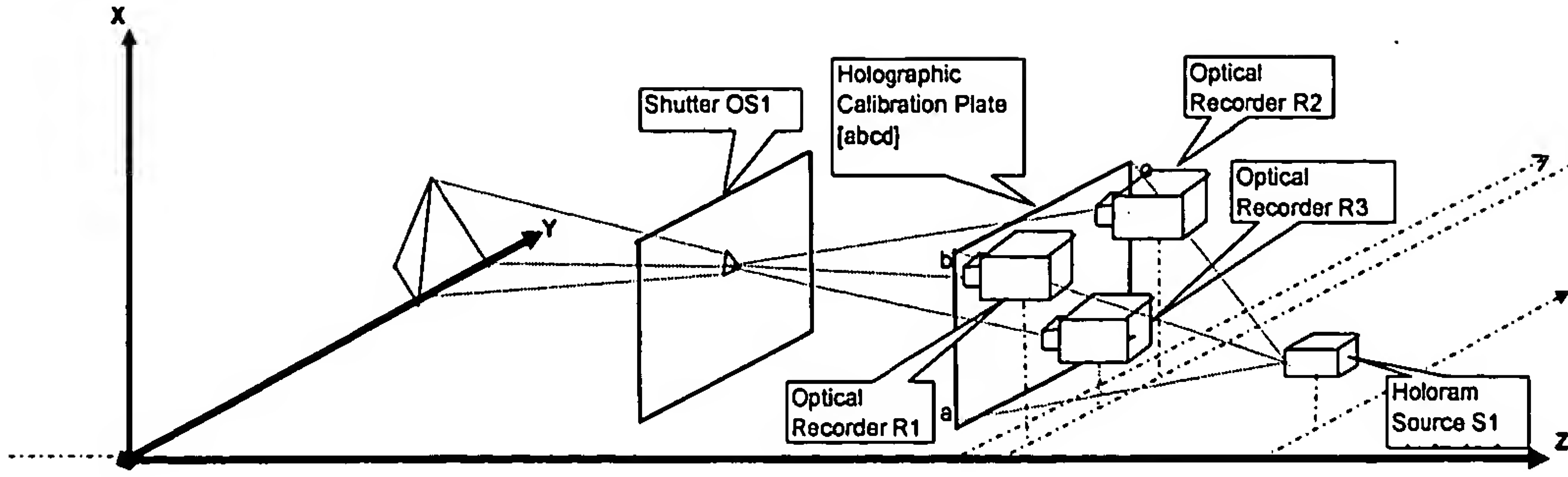
Alignment and Calibration of Image Scanner with Multiple Optical Recorders using Holograms and Mirror
Figure 1a



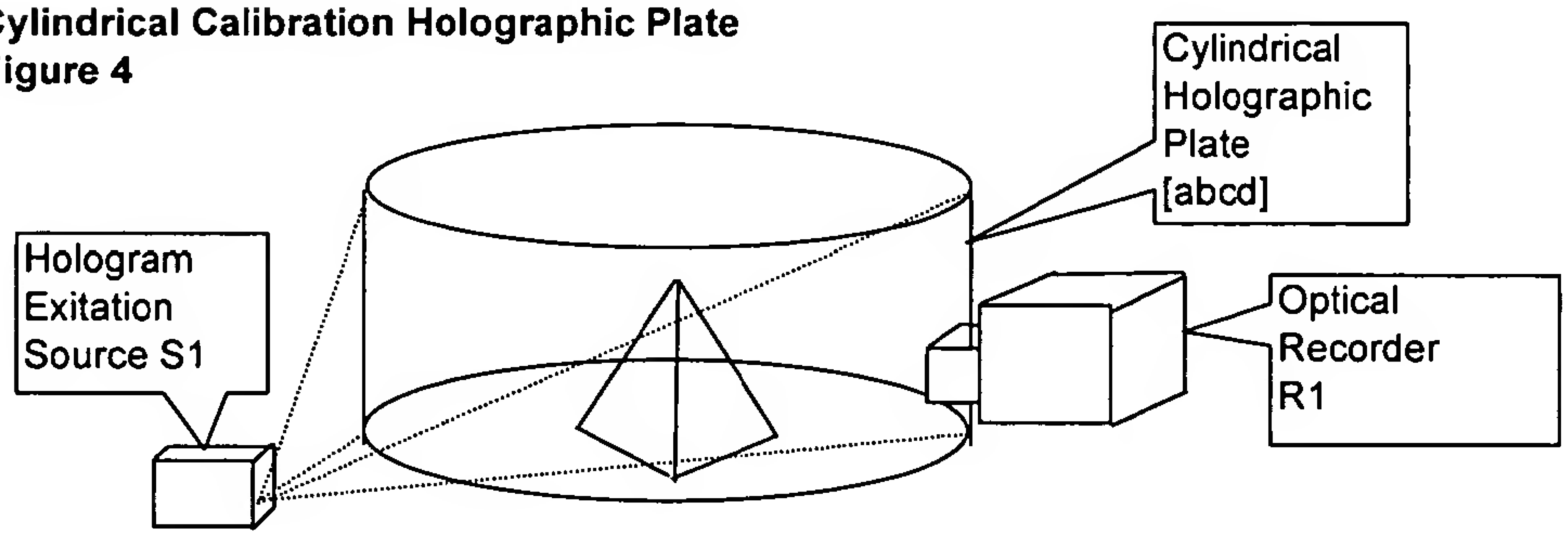
Type 1 Optical Recorder Device
Figure 2



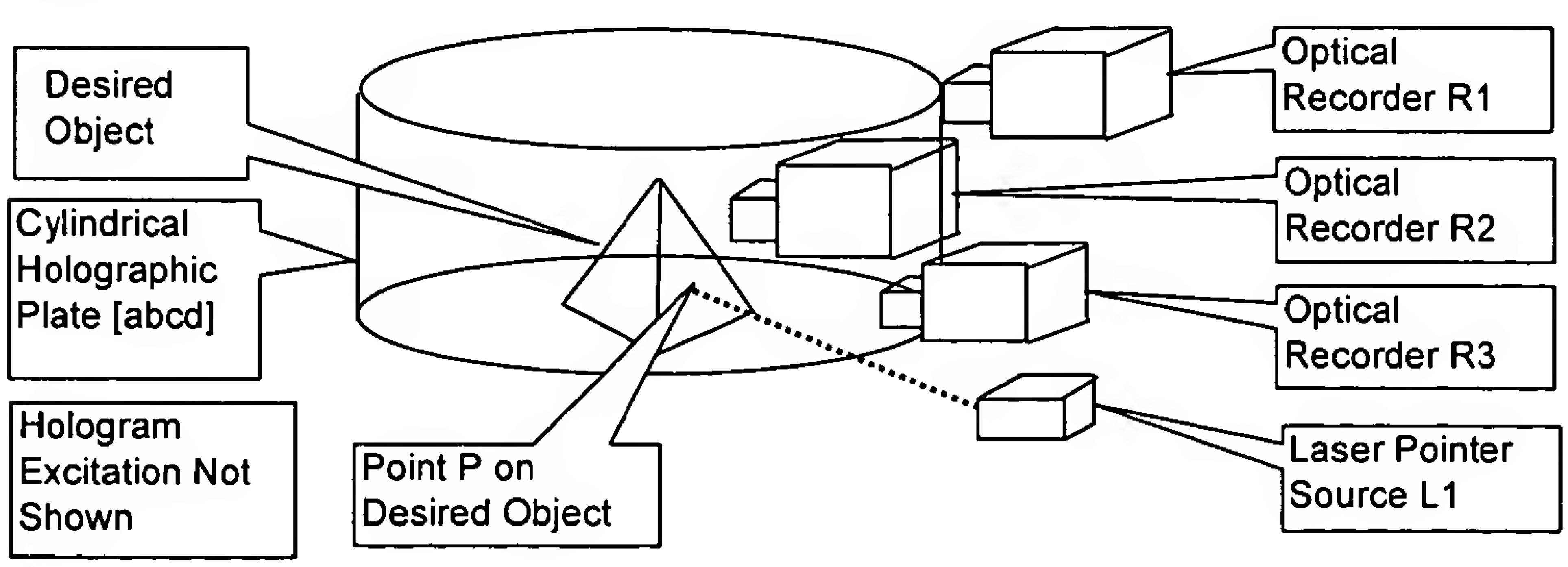
Type 2 Optical Recorder Device
Figure 3



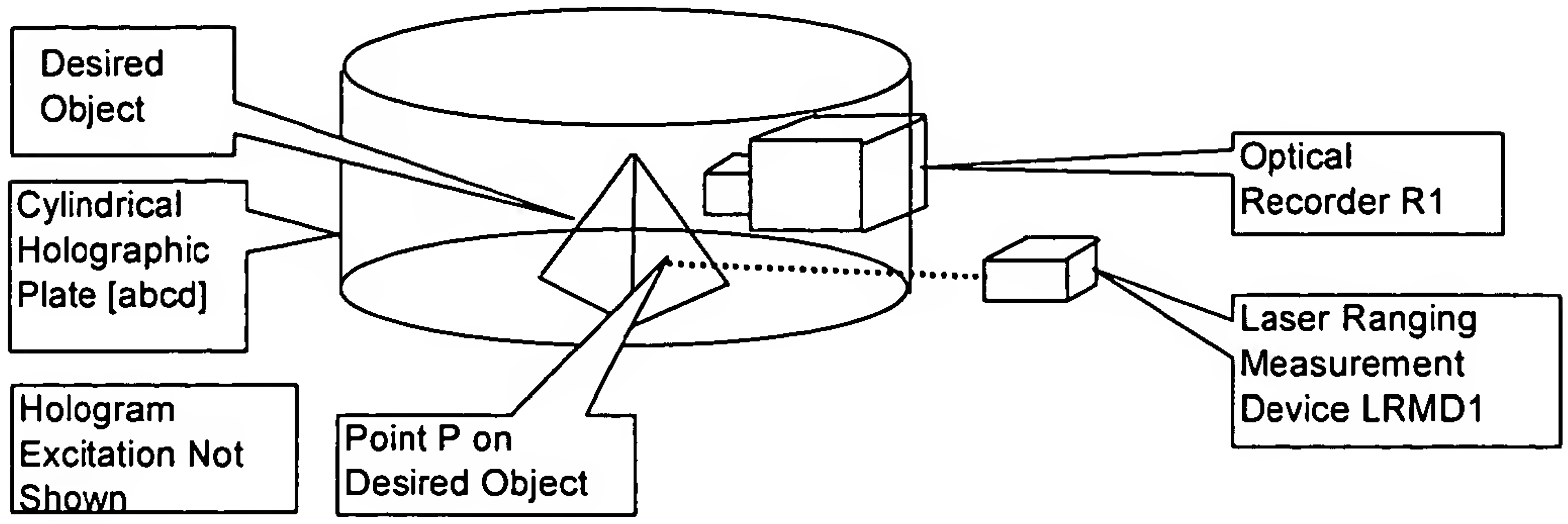
Cylindrical Calibration Holographic Plate
Figure 4



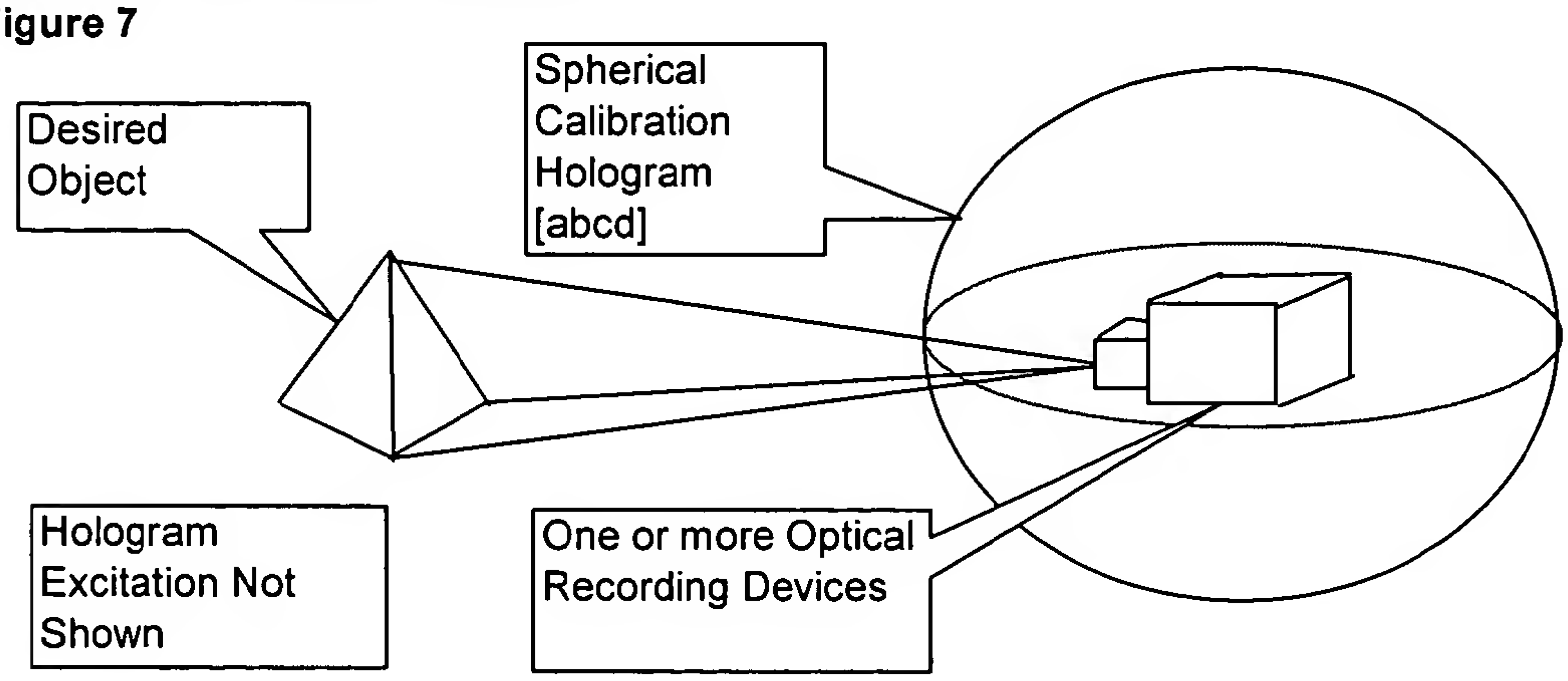
Sterographic 3 Dimensional Capture
Figure 5



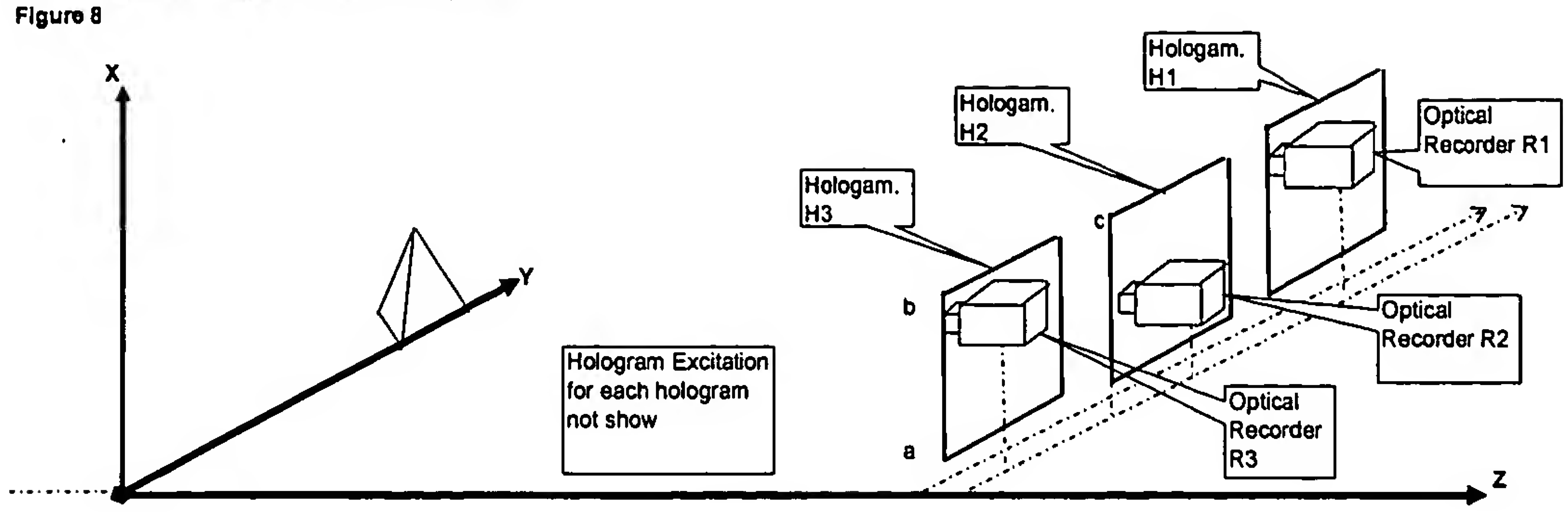
Sterographic 3 Dimension Extraction With Las r Ranging
Figure 6



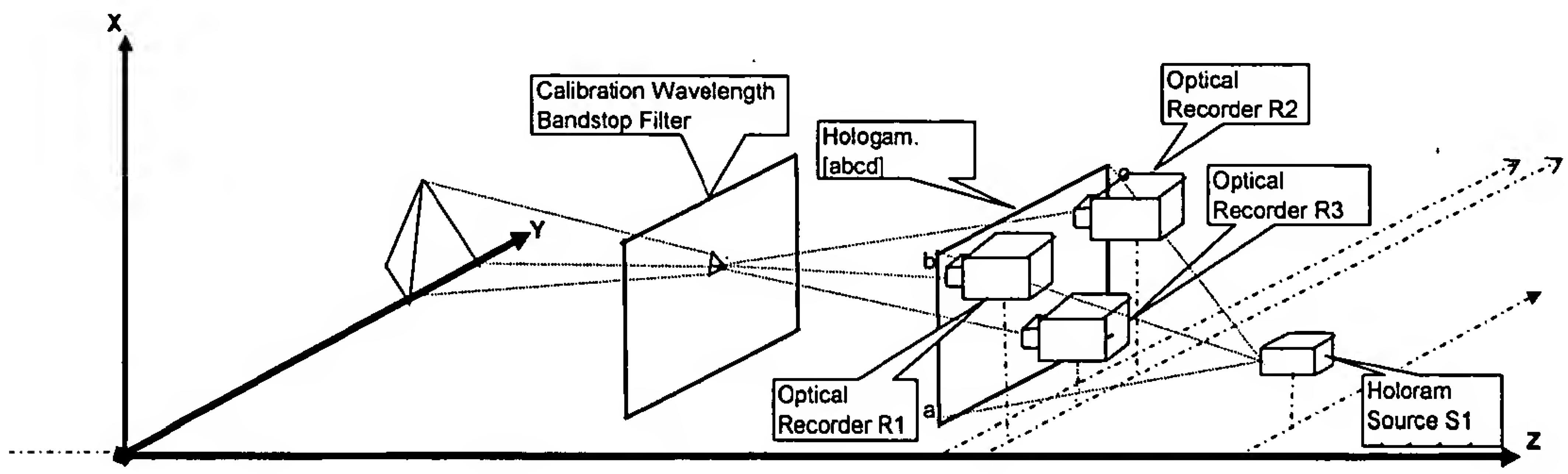
Spherical Calibration Hologram
Figure 7



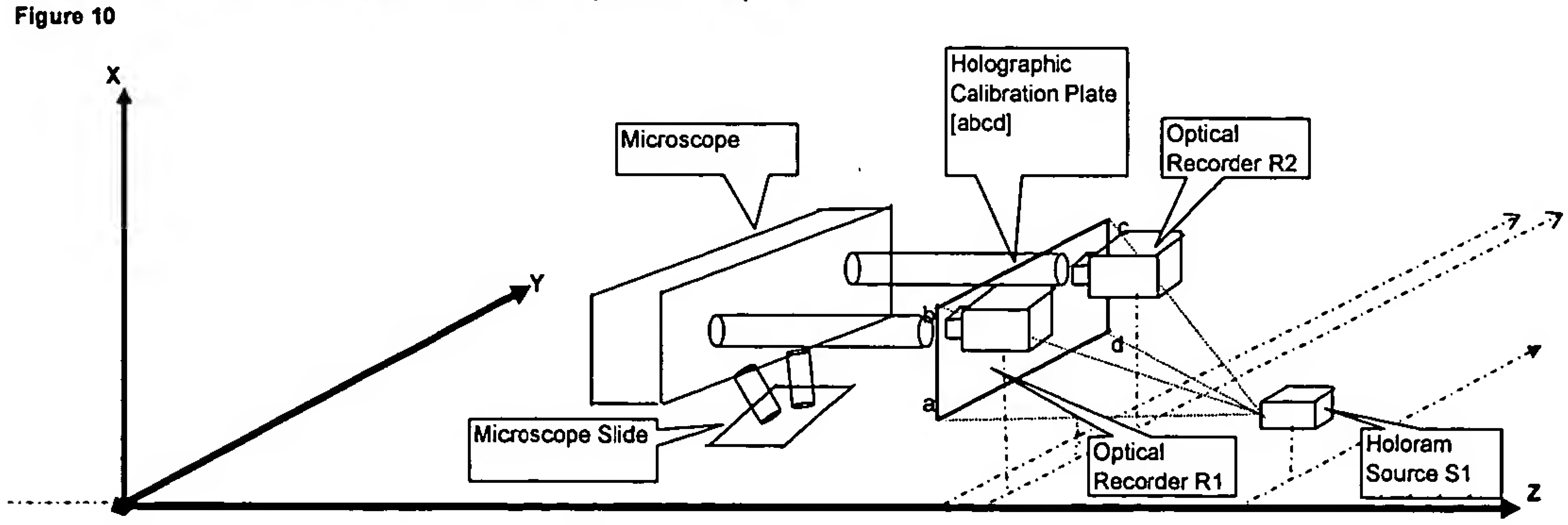
Non-contiguous holographic calibration plates
Figure 8



Concept for Alignment and Calibration of Image Scanner with Multiple Optical Recorders using Holograms for Security Applications
Figure 9



Projection of Measurement Grids for Mono and Steroptic Microscopes
Figure 10



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